ANALYZING THE DETERMINANTS OF FREIGHT SHIPPERS' BEHAVIOR: OWN ACCOUNT VERSUS PURCHASED TRANSPORT.

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ABSTRACT

Previous work in the demand for freight transportation has focused in the rail-truck substitution problem, leaving aside the prior own-account versus third-party trade-off, often found in transportation decision-making. The purpose of this paper is to analyze shippers' behavior relative to this question, paying particular attention to whether the decision to use a private form of transport is taken on a short term or on a medium term horizon. In order to provide a quantitative evaluation, as an illustrative case, the models developed are tested on data gathered by means of a sample survey conducted to Andalusian enterprises belonging to the food industry.

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1.- INTRODUCTION

Domestic freight transport in Andalusia takes place mostly by road. Its market share goes from 97%, when measured in terms of total tons, to 91%, when ton-kilometers are considered. Tables 1 and 2 present the relative weights of different transport modes for five broad commodity classes.

As can be seen, road's supremacy is completely out of question. Only for chemical and petroleum products does truck transport have some competition from pipelines and maritime transport. Remaining product classes show a total dependence on road transport.

Notwithstanding, most road shippers do have a choice between own-account operations and purchased transport. Table 3 shows relative weights of these kinds of transport for Spain as a whole[1]. Own account transport represents almost 30% of the total tons dispatched by road for many commodity classes.

Nevertheless, most freight transport demand studies investigate the rail-truck substitution problem. Considerably less effort can be found analyzing the determinants of road transport, specifically relating to the choice between internal -own account- transport and external –purchased- transport.[2] As Fridstrom and Madslien (2002) state, it is poorly understood why so many companies choose to own and operate their own vehicles, rather than purchase the necessary freight services in the market.

The purpose of this paper is to analyze the freight transportation decision-making process. Given the above dissertation, particular attention is paid to the internal-external trade-off and to whether the decision to use own account transport is taken on a short term or on a medium term horizon. In order to provide a quantitative evaluation of shippers' behavior, as an illustrative case, the models developed are tested on data gathered by means of a sample survey conducted to Andalusian enterprises belonging to the food industry.

The study is organized as follows. Section 2 presents a review of existing approaches towards modeling the demand for freight transport. Section 3 introduces the theoretical model. Section 4 discusses the econometric model to be used in the

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[1] No detailed information has been found for Andalusia.

[2] This is in marked contrast with present passenger demand modeling, where the paradigm has been the research of the public versus private trade-off, prior to the study of transport mode choice. See, for

empirical analysis. The data and variable construction are described in section 5. Empirical results are given in section 7. And finally, section 8 debates possible improvements and conclusions.

TABLE 1.- MARKET SHARE OF DIFFERENT TRANSPORT MODES FOR COMMODITY CLASSES. TRAFFIC FLOWS MEASURED IN TONS. Andalucía. 2001					
Source: Encuesta Permanente del Transporte por Carretera and unpublished data supplied by RENFE and CLH. S.A.					
	ROAD	RAIL	PIPE	SEA	TOTAL
Food and agricultural products	97.03	0.44	-	2.53	100.00
Construction and mineral fuels	99.05	0.36	-	0.59	100.00
Chemical and petroleum products	89.48	1.50	3.97	5.06	100.00
Metal products	98.00	0.82	-	1.18	100.00
Machines, vehicles and other products	97.73	0.54	-	1.73	100.00
TOTAL	97.23	0.56	0.45	1.76	100.00

TABLE 2.- MARKET SHARE OF DIFFERENT TRANSPORT MODES FOR COMMODITY CLASSES. TRAFFIC FLOWS MEASURED IN TON-KILOMETERS. Andalucía. 2001					
Source: Encuesta Permanente del Transporte por Carretera and unpublished data supplied by RENFE and CLH. S.A.					
	ROAD	RAIL	PIPE	SEA	TOTAL
Food and agricultural products	92.21	1.47	-	6.32	100.00
Construction and mineral fuels	94.11	1.25	-	4.63	100.00
Chemical and petroleum products	74.67	5.05	5.31	14.96	100.00
Metal products	94.03	3.20	-	2.77	100.00
Machines, vehicles and other products	95.65	0.72	-	3.63	100.00
TOTAL	91.16	1.89	0.72	6.23	100.00

TABLE 3.- MARKET SHARE OF OWN ACCOUNT OR HIRE FREIGHT FOR COMMODITY CLASSES. TRAFFIC FLOWS MEASURED IN TONS. Spain. 2002			
Source: Encuesta Permanente del Transporte por Carretera.			
	OWN- ACCOUNT	PURCHASED	TOTAL
Food and agricultural products	26.14	73.85	100
Construction and mineral fuels	31.81	68.18	100
Chemical and petroleum products	14.67	85.32	100
Metal products	23.81	76.18	100
Machines, vehicles and other products	20.30	79.69	100
TOTAL	28.39	71.60	100

instance, Ben Akiva and Learman (1985, pp.276-321, 323-372), Ortúzar and Willumsen (1990, pp.179-198) or Matas (1991).

2.- THE DEMAND FOR FREIGHT TRANSPORTATION: THE STATE OF THE ART

According to Kanafani (1983, p.280), there are three basic approaches to the analysis of commodity transportation demand: the input-output approach, spatial interaction modeling and the microeconomic perspective.

In the first case, interrelations between sectors of an economy are analyzed. With transportation identified as one of the sectors, it becomes possible to investigate transportation requirements of the other sectors and to translate those into flows of goods. The multiregional models of Leontieff and Strout (1963) or Liew and Liew (1985) are qualified samples of this kind of analysis.

The second approach of spatial interaction modeling is aggregate in nature. Surpluses and deficits of commodities are located at various points of space and a process is then postulated whereby flows of commodities occur from points of excess supply to points of excess demand. Generally, the transportation system is explicitly represented by a network, with its nodes and arcs, and considerable effort is placed on assigning traffic flows to that network. To this group belong studies like the seminal Harvard-Brookings model of Kresge and Roberts (1971) or, more recently, Harker's (1987) generalized spatial price equilibrium model.

Finally, we find the microeconomic approach, also called econometric, in which the basic decision unit of analysis is the firm, considered the potential user of transportation. In this approach, the demand for freight transportation is derived by considering transportation as one of the inputs into the production or marketing process of the firm. Cross-section or longitudinal data relating to different enterprises or producing sectors are used to develop structural relationships describing shipper's behavior. Let us review this last perspective in more detail.

Following Winston (1983), microeconomic models can be classified into aggregate and disaggregate, depending on the nature of the data employed. In the aggregate studies, the data consists of total flows by mode at the regional or national level. In the disaggregate studies, the data consists of information relating to individual shipments.

In general, aggregate models have tended to be based on cost minimizing behavior by firms. Good examples can be found in Oum (1979a, 1979b), Friedlaender and Spady (1980), or, lately, Bianco, Campisi and Gastaldi (1995). Although, from a theoretical point of view, disaggregate models seem preferable to aggregate ones, in particular contexts, aggregate models can turn more useful than their disaggregate counterparts. Especially, if cost limitations preclude an adequate sampling of the population of a large-scale policy analysis, an aggregate methodology can become the best choice on practical grounds.

Notwithstanding, disaggregate models hold a number of important conceptual strengths (Small and Winston, 1999). First, the number of observations is much larger, leading to more precise estimates of parameters. Second, the disaggregate approach is conducive to much richer empirical specifications, thus better capturing the variation in characteristics of the shipper. Finally, dissagregate models do not require the unrealistic assumption of identical decision-makers as aggregate models do. Therefore, one can conclude that the dissagregate methodology should be used whenever possible.

In the literature, dissagregate models are, in turn, classified as behavioral and inventory (Winston, 1983 and Zlatoper and Austrian, 1989). In the first case, the decision-maker is the physical distribution manager of the receiving or shipping firm. It is assumed that shipment size, dependent on the purchasing department, is exogenous to this agent. In consequence, only mode choice is modeled. Given there is uncertainty relative to the quality of service effectively obtained, the shipper is postulated to maximize his expected utility from his choice of mode. Empirically, a random expected utility model is used.

The inventory-based models, on the other hand, attempt to analyze freight demand from the perspective of the logistic manager. As first noted by Baumol and Vinod (1970), freight in transit can be considered to be an inventory on wheels. Accordingly, in-transit carrying costs and inventory costs must be added to direct transport costs in order to attain an adequate picture of the options opened to the decision-maker. From this point of view, the logistic manager faces a trade-off, as a greater shipment size probably diminishes unit transport costs but, in turn, it implies a larger stock for the good in question.

The models contained in Winston (1981), Daughety and Inaba (1978, 1981), Ortúzar (1989) or Jiang, Johnson and Calzada (1999) constitute applied examples of the behavioral approach. Recently stated preference data have been used to estimate behavioral models, as in Fowkes and Shinghal (2002) or Fridstrom and Madslien (2002). Nevertheless, most empirical work has tended to be based on the inventory-theoretic framework. The initial models of Roberts (1977) and Roberts and Chiang

(1984) considered only discrete options; the paradigm is now the joint estimation of discrete and continuous choices, first considered by McFadden, Winston and Boersch-Supan (1985). Later refinements of this original model can be found in Inaba and Wallace (1989), Abdelwahab and Sargious (1992), Genç, Inaba and Wallace (1994) or Abdelwahab (1998).

3.- A FREIGHT TRANSPORT DEMAND MODEL

As Abdelwahab and Sargious (1992) state, the demand for freight transportation is determined by a complex hierarchy of choices. This hierarchy can be structured on the basis of the time lag involved in changing decisions in response to changes in the situation[3].

In the long-run, the company defines its nature and location and probably also its size and structure. The firm makes long-term decisions, which correspond to the top level of the decision pyramid.

On a second level, firms take strategic decisions. They decide on the level of production, the spatial distribution of inputs or outputs, the inventory strategy and other medium-term matters.

Finally, there is the operational level where firms take short-term logistics decisions like the choice of transport mode and shipment size.

In this paper, we analyze the demand for freight transport from the perspective of a logistic manager, who wishes to minimize the total logistics costs that his firm incurs. Concretely, we study whether the decision to use a private form of transport is taken on a short term or on a medium term horizon. In the first case, the decision of which form of transport to use would belong to the operational level and would be taken together with shipment size. In the second case, the choice of transport alternative would relate to the strategic level and depend on longer-term variables like the type of product or the size of the company.

In order to make the problem manageable, it is assumed that all other long run decisions, like location, firm size, or marketing policy, have already been taken. Furthermore, it is stated that the choice of supplier - or client, depending on the cases –

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[3] The following hierarchy structure is adapted basically from Bolis and Maggi (2002).

is also given. We can thus concentrate on the determinants of which transport alternative to choose.

The logistic manager wishes to minimize total logistic costs of the firm. Those costs, as Baumol and Vinod (1970) first stated, consist of direct shipping costs, in-transit carrying costs, ordering costs and storage costs. If own account is used, vehicle maintenance costs must be added to those. All these costs are a function of different freight demand characteristics. Following Jiang et al. (1999) we will consider three different classes of variables:

- Transport-type characteristics, **s**, such as rates, transit time or reliability of the two alternatives.
- Commodity attributes, $\mathbf{s}^{\mathbf{k}}$, such as its value, density or state.
- Firm characteristics, $\mathbf{s}^{\mathbf{m}}$, such as company's size, total sales, total transport expenditures or spatial influence zone.

Consequently, the optimized logistic costs function becomes:

$$C^{*} = C^{*}(\mathbf{s}, \mathbf{s}^{\mathbf{k}}, \mathbf{s}^{\mathbf{m}}) \qquad [1.]$$

As assumption, if this logistic decision is taken in the short run, the inventory manager will control two decision variables: shipment size and transport-type alternative – either own account or purchased transport. On the other hand, if it is taken in the medium run, he will only decide on the transport alternative. This choice will be fundamentally guided by longer-term variables like the type of product or the size of the company.

Let us see how these ideas are translated into econometric models.

4.- TWO CONCEIVABLE ECONOMETRIC MODELS

In the real world, the analyst is likely to fail to observe all factors influencing transport behavior. Besides, observed variables may contain measurement errors. Therefore, the optimized transport costs function depends not only on the observed exogenous variables, but also on an unobservable error term.

$$C^{*} = C^{*}(\mathbf{s}, \mathbf{s}^{\mathbf{k}}, \mathbf{s}^{\mathbf{m}}, \varepsilon) \qquad [2.]$$

Let us consider first that the transport choice is taken at the strategic level. The firm minimizes logistics costs by choosing either own account or purchased transportation. Shipment size is not considered relevant, as it will be decided later on a day to day basis.

The company will rely on service attributes, product characteristics and firm conditions to take its decision, but considerably more emphasis will be observed on the effect of product and firm characteristics. The transport choice will be taken conditional on those longer-term circumstances.

An index I^* can be constructed representing the amount of cost savings obtained by choosing one transport alternative over the other. Formally:

$$I^* = C_2^* - C_1^* \qquad [3.]$$

so that alternative 2 (purchased transport) is chosen when the index is positive and alternative 1 (own-account transport), when it is negative.

In practice, this index's value cannot be known. What the analyst observes is a dummy variable, which takes value 1 when the index is positive (and purchased transportation is chosen) and value 0 when the index is negative (and own-account is the elected alternative). The index relies on the exogenous variables found for the logistics costs function. Approximating by a linear function:

$$I^* = \alpha_0 + \alpha_1 \mathbf{s} + \alpha_2 \mathbf{s^k} + \alpha_3 \mathbf{s^m} + u \qquad [4.]$$

And then:[4]

$$\begin{aligned} \Pr(I^* = 1) &= \Pr(u > \alpha_0 + \alpha_1 \mathbf{s} + \alpha_2 \mathbf{s^k} + \alpha_3 \mathbf{s^m}) = \\ &= 1 - F(\alpha_0 + \alpha_1 \mathbf{s} + \alpha_2 \mathbf{s^k} + \alpha_3 \mathbf{s^m}) \end{aligned} \qquad [5.]$$

where F is the cumulative distribution function for u. If we assume that the errors u are $IN(0, \sigma^2)$, we obtain the probit model, that can be estimated by maximum likelihood.

Let us now turn to the operational level model. For each transport alternative, there is an optimal shipment size, relying direct or indirectly on the preceding variables:

$$X_i^* = X_i^*(\mathbf{s}, \mathbf{s^k}, \mathbf{s^m}, \varepsilon) \qquad i=1,2 \qquad [6.]$$

This can be approximated by a linear functional form in the following way:

$$X_i^* = \beta_{0i} + \beta_{\mathbf{1i}} \mathbf{s} + \beta_{\mathbf{2i}} \mathbf{s^k} + \beta_{\mathbf{3i}} \mathbf{s^m} + \varepsilon_i \qquad i=1,2 \qquad [7.]$$

Conditional on $\mathbf{s}$, $\mathbf{s^k}$, and $\mathbf{s^m}$, the firm is observed to ship X_1^* if $C(1, X_1^*) < C(2, X_2^*)$. In order to ease model estimation, an index I^* can be

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[4] Maddala (1983, p.22).

constructed representing the amount of cost savings obtained by choosing one transport alternative over the other. That is, alternative 1 (purchased transport) is chosen if the index is positive and alternative 2 (own-account transport), when it is negative. Formally:

$$I^* = C\left(2, X_2^*\right) - C\left(1, X_1^*\right) \qquad [8.]$$

From the analyst's point of view, this index's value cannot be known, only its sign can. The index relies on the exogenous variables found for the logistics costs function, as before, and on the endogenous shipment size variables. For the same reasons stated above, also an error term appears.

$$I^* = I^*(\mathbf{s}, \mathbf{s}^\mathbf{k}, \mathbf{s}^\mathbf{m}, X_1^*, X_2^*, \nu) \qquad [9.]$$

Approximating by a linear function:

$$I^* = \delta_0 + \delta_\mathbf{1}\mathbf{s} + \delta_\mathbf{2}\mathbf{s}^\mathbf{k} + \delta_\mathbf{3}\mathbf{s}^\mathbf{m} + \eta_1 X_1^* + \eta_2 X_2^* - \nu \qquad [10.]$$

As a result, the short-term econometric model to be used in the empirical analysis is completely specified by the following system of simultaneous equations:

$$X_1^* = \beta_{01} + \beta_\mathbf{11}\mathbf{s} + \beta_\mathbf{21}\mathbf{s}^\mathbf{k} + \beta_\mathbf{31}\mathbf{s}^\mathbf{m} + \varepsilon_1 \qquad [11.]$$

$$X_2^* = \beta_{02} + \beta_\mathbf{12}\mathbf{s} + \beta_\mathbf{22}\mathbf{s}^\mathbf{k} + \beta_\mathbf{32}\mathbf{s}^\mathbf{m} + \varepsilon_2 \qquad [12.]$$

$$I^* = \delta_0 + \delta_\mathbf{1}\mathbf{s} + \delta_\mathbf{2}\mathbf{s}^\mathbf{k} + \delta_\mathbf{3}\mathbf{s}^\mathbf{m} + \eta_1 X_1^* + \eta_2 X_2^* - \nu \qquad [13.]$$

This is the switching regression model with endogenous switching considered by Maddala (1983, pp.223-28) and Greene (1999, pp.839-848). In our particular case, the criterion function corresponds to equation [13] and the two possible regimes to equations [11] and [12].

As it can be observed, the criterion function depends on the endogenous variables X_1^* and X_2^*. In order to estimate equation [13] as a binary choice model, we must transform it into an equation which consists of only predetermined variables. This can be achieved by substituting the values of X_1^* and X_2^* from equation [11] and [12] into equation [13] to get the reduced form equation. The final specification of the model is thus:[5]

[5] Equations [14] and [15] correspond exactly to equations [11] and [12], but are repeated here to gain a complete vision of the model to be estimated.

$$X_1^* = \beta_{01} + \beta_{11}\mathbf{s} + \beta_{21}\mathbf{s^k} + \beta_{31}\mathbf{s^m} + \varepsilon_1 \quad [14.]$$

$$X_2^* = \beta_{02} + \beta_{12}\mathbf{s} + \beta_{22}\mathbf{s^k} + \beta_{32}\mathbf{s^m} + \varepsilon_2 \quad [15.]$$

$$I^* = \theta_0 + \theta_1\mathbf{s} + \theta_2\mathbf{s^k} + \theta_3\mathbf{s^m} - \varepsilon \quad [16.]$$

The error terms in these equations are correlated. Consequently, joint estimation of the system of equations is required. In this paper, we will follow the two-stage 'Heckit' method[6], whereby a maximum likelihood probit is applied to estimate the alternative criterion function in the first stage, and ordinary least-squares are used to adjust the shipment size equations in the second stage. A brief description of this procedure is given in Appendix 1.

5.- DATA AND VARIABLE CONSTRUCTION

As already stated, the data used in the empirical analysis were collected from a questionnaire survey conducted, in 1999, on a sample of Andalusian agro-industrial enterprises. The sample population was taken from the business directory of the Central de Balances, Junta de Andalucía.[7]

Every respondent was requested to provide information on characteristics of his enterprise, characteristics of his main product and characteristics of the transport service used for most shipments of that product.

The resulting database contains 106 observations, representing the corresponding number of typical shipments encountered in the food sector. Of these, 59 cases relate to purchased transportation and 47, to own-account transportation. For each one, a set of features is recorded, basically transport-type attributes, commodity characteristics and firm features.

The variable ACCOUNT records whether the freight service is purchased (value 1) or provided internally (value 0).

The variables characterizing the good transported include: VALUE, in monetary units per unit of weight; PERISHABLE, a dummy variable (1 if the good is perishable,

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[6] Apparently, a first version of the procedure was presented by Heckman (1976) "The common structure of statistical models of truncation, sample selection and limited dependent variables and a simple estimator for such models", *Annals of Economic and Social Measurement* vol.5, pp.475-492, cited by Maddala (1983, p 221). We will follow Lee's (1976) extension of this model.

[7] Instituto de Fomento de Andalucía et al. (1999).

0 otherwise); ALIVE, a dummy variable (1 if the merchandise consists of live animals, 0 otherwise); BULK, a dummy variable (1 if the merchandise is transported in bulk units, 0 otherwise); and RELATION, also a dummy variable (1 if the commodity is an output, 0 when it corresponds to an input).

Three firm characteristics can be considered: total sales, annual volume to be shipped and total transport costs involved. The variable SALES records total revenue of the firm. It is a measure of firm's size. ANNUAL refers to total annual volume shipped of the commodity. TOTALCOS computes total transport costs incurred by the firm during the year. An additional variable can be calculated: the importance of transport costs with respect to the annual sales volume. We will refer to this variable as TRANRATIO.

Finally, there are some shipment characteristics: its size, time, unitary cost and distance.[8] The variable SIZE refers to the amount transported, measured in weight units, in an individual shipment. TIME measures the duration of transport. For each shipment, the variable UNICOST registers the monetary cost per ton moved. It can be considered the fare for the purchased transport. Finally, the variable DISTANCE records the length of the service.

Table 4 presents a description of these variables for own account and purchased shipments, as well as for the entire data set.

[8] Respondents were also asked about the variability of transport time but the quality of the data obtained was very poor.

TABLE 4.- DESCRIPTION OF THE AVAILABLE VARIABLES				
Source: Mail questionnaire. Calculations performed using LIMDEP, version 7.0.[9]				
		MEAN (STANDARD DEVIATION)		
VARIABLE	UNIT	PURCHASED	OWN ACCOUNT	TOTAL
ACCOUNT	0/1			0.56 (0.49)
VALUE	Ptas/kg	513.35 (1071.42)	442.64 (616.62)	481.32(891.71)
PERISHABLE	0/1	0.42 (0.49)	0.59 (0.49)	0.50 (0.50)
ALIVE	0/1	0.12 (0.32)	0.05 (0.23)	0.09 (0.28)
BULK	0/1	0.18 (0.39)	0.15 (0.36)	0.17 (0.37)
RELATION	0/1	0.45 (0.50)	0.80 (0.39)	0.61 (0.48)
SALES	Thous. Ptas.	4395.50 (11285.14)	1315.78 (3841.13)	3029.97 (8898.03)
ANNUAL	Tons.	3338.00 (6260.48)	2137.39 (5182.65)	2766.28 (5776.56)
TOTALCOS	Thous. Ptas.	13.07 (25.32)	5.25 (8.47)	9.61 (20.02)
TRANRATIO	Thousand	11.51 (22.15)	9.26 (13.14)	10.51 (18.65)
SIZE	Tons	16.20 (14.58)	9.39 (7.31)	13.18 (12.35)
TIME	Days	1.68 (2.04)	0.95 (0.59)	1.33 (1.57)
UNICOST	Ptas/tons.	9.95 (14.84)	7.71 (10.15)	8.95 (12.95)
DISTANCE	Km.	658.22 (1160.10)	211.72 (209.01)	460.24 (901.23)
N. Observations		59	47	106

At a first sight, the variables behave differently for the two options considered. In all the cases, both average values and data dispersion are larger for the external transport alternative than for the internal one.

As first noted by Quandt and Baumol (1966), the choice of transport mode is guided by the relative attractiveness of the options. This implies, as clearly stated by Winston (1983), that one needs data on the characteristics of all modes, either chosen or unchosen. In our case, there are only two options: own account or purchased transport, and two service attributes: unit cost and transit time. As we lack information on the attributes corresponding to the rejected option, we must predict them.

However, selection effects could be found in these predictions. That is, if companies choose the alternative that offers the best time-cost trade-off, we could obtain that the observed distribution of either unit costs or transit times turns out to be somewhat lower than the full distribution of these variables available to firms. Thus, we may have to correct for sample selection in our predictions.

To test for sample selection, we use a two-stage procedure, similar to the Heckit method described in Appendix 1. In the first stage, a correction factor is derived from the probit estimation of the probability of using purchased transport. In the second stage actual unit costs (or times) are regressed on other explanatory variables and on the selectivity correction factor by ordinary least squares. If the selectivity variable appears

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[9] All the calculations were performed using the LIMDEP package, version 7.0. We thank Prof. Dr. Manuel Jaén for providing us with a copy of this software.

to be significant then sample selection can not be rejected and the model is used to predict the values of unit cost (or time) for the non-chosen option. In case the selectivity variable is not statistically significant, an alternative model without correction factors is used for the predictions.

For the variable UNICOST, the inclusion of the correction factors improved the explanatory power of the models. In the case of TIME, the models without corrections behaved better. Appendix 2 shows the models finally used in the predictions.

In order to get an adequate picture of the calculations involved, Table 5 presents means and standard deviations of the predicted variables, compared to their actual values. The estimation of the final models uses actual values for the chosen option and predicted values for the rejected one (as considered for the last row).

TABLE 5.- ACTUAL AND PREDICTED VALUES FOR UNICOST AND TIME

Source: Mail questionnaire. Calculations performed using LIMDEP, version 7.0.

	Mean (Standard Deviation)			
	UNICOST		TIME	
	PURCHASED	OWN ACCNT.	PURCHASED	OWN ACCNT.
ACTUAL[a]	9.95 (14.84)	7.71 (10.15)	1.68 (2.04)	0.95 (0.59)
PREDICTED FOR ALL[b]	15.35(7.85)	13.31 (8.98)	1.49 (0.76)	1.23 (0.78)
ACTUAL & PREDICTED[c]	15.18 (12.78)	13.25 (10.89)	1.49 (1.57)	1.20 (0.84)

a. Only actual values reported.
b. Predicted values for all respondents.
c. Actual values for users, predicted values for nonusers.

6.- ESTIMATION RESULTS

As already stated, the operational short-term model posits that the transport-type choice and the shipment-size decision are generated from the same optimization problem. From a statistical point of view that requires the joint estimation of the equation governing the transport-alternative selection together with the equations relative to the shipment size for each option. Therefore, equations [14], [15] and [16] have been estimated by the two-stage 'Heckit' method described in Appendix 1. Final specification of the model has been achieved by testing minor changes in the choice of explanatory variables.[10].

[10] All of them were subject to a cause and effect relationship with the dependent variables, but some simply could not be included simultaneously due to its mutually high correlation. That was the problem encountered between the variables distance and travel time. Only the last one was finally chosen.

The first stage of the estimating strategy calls for the estimation of the reduced form choice index [equation 16]. The results of the probit estimation are reported in Table 6. The two service attribute variables, unit cost and time, are included in difference form, for it is their relative value that guides choices.

Some of the variables, like PERISHABLE, ALIVE or ANNUAL are not very significant. From the econometric point of view, they should have been eliminated of the final specification. However, its inclusion in the probit model is mandatory: theoretically, if they were part of the shipment size equations, they had to be part of the reduced form of the criterion function too.

The estimation results of equations [14] and [15], corresponding to the two shipment size equations, are reported in Tables 7 and 8, respectively. Clearly, the selection term (LAMBDA) is not significant in neither case. Besides, the values of the correlation (RHO) between error term in the reduced form criterion equation (equation [16]) and the error terms in both of the shipment size equations ([14] and [15]) are relatively low. We can conclude then that the hypothesis of interdependence between the decisions on transport-type and shipment size is not supported and consequently the operational level model is not corroborated.

TABLE 6.- REDUCED FORM EQUATION. PROBIT MODEL. FIRST STAGE				
Source: Mail questionnaire. Calculations performed using LIMDEP, version 7.0.				
Dependent var. :ACCOUNT NOBS.=106				
Max. Log Likelihood Func. = -39.42409 | Rest. Log. Likelihood.= -66.36152| Chi-squared 53.87486 Degrees of freedom 6 | Significance level .0000000				
Variable	Coefficient	Standard Error	Coef./Stand. Er.	Probability
CONSTANT	1.123	0.394	2.848	0.0044
RELATION	-1.293	0.411	-3.143	0.0017
UNICOST1-UNICOST2	-0.056	-0.010	-5.441	0.0000
TIME1-TIME2	0.084	0.193	0.439	0.6603
PERISHABLE	0.032	0.372	0.087	0.9309
ALIVE	0.370	0.644	0.575	0.5656
ANNUAL	0.19E-05	0.15E-03	0.012	0.9901

TABLE 7.- SHIPMENT SIZE EQUATION. OLS. (PURCHASED TRANSPORT)				
Source: Mail questionnaire. Calculations performed using LIMDEP, version 7.0				
Dep. var.: SIZE NOBS.=59 N Parameters =6 Deg. Fr. =53				
R squared = 0.27556 Adjusted R squared =0.2045 Model test: F[5, 53] = 3.88 Prob. Value .00468				
RHO1 (Correlation of disturbance and selection criterion)= -0.08799				
Variable	Coefficient	Standard Error	Coef./Stand. Er.	Probability
CONSTANT	23.574	2.964	7.953	0.0000
RELATION	-10.345	3.822	-2.708	0.0068
PERISHABLE	4.791	3.749	1.278	0.2014
ALIVE	-7.754	5.741	-1.351	0.1768
UNICOST1	-0.306	0.235	-1.300	0.1935
LAMBDA1	-1.100	7.095	-0.155	0.8767

TABLE 8.- SHIPMENT SIZE EQUATION. OLS. (OWN-ACCOUNT TRANSPORT)				
Source: Mail questionnaire. Calculations performed using LIMDEP, version 7.0				
Dep. var.: SIZE NOBS.=49 N Parameters =8 Deg. Fr. =41				
R squared = 0.66415 Adjusted R squared =0.5988 Model test: F[7, 41] = 10.17 Prob. Value 0.00000				
RHO2 (Correlation of disturbance and selection criterion)= 0.01004				
Variable	Coefficient	Standard Error	Coef./Stand. Er.	Probability
CONSTANT	15.138	22.871	0.662	0.5080
RELATION	-10.384	9.284	-1.119	0.2633
ANNUAL	0.205	0.207E-02	0.989	0.3244
TIME2	1.236	1.496	0.826	0.4085
LAMBDA2	0.059	33.654	0.002	0.9986

For the strategic level decision model, the transport-type option is taken conditional on other circumstances like product characteristics, firm conditions and service attributes. Table 9 presents the results of the estimations. As can be seen the overall fit of the model, as expressed by the significance level of the chi-squared test, is relatively good.

TABLE 9.- BINOMIAL PROBIT MODEL. MLE				
Source: Mail questionnaire. Calculations performed using LIMDEP, version 7.0.				
Dependent var. :ACCOUNT NOBS.=106				
Max. Log Likelihood Func. = -36.99156 Rest. Log. Likelihood.= -66.36152| Chi-squared 58.73991 Degrees of freedom 4 | Significance level .0000000				
Variable	Coefficient	Standard Error	Coef./Stand. Er.	Probability
CONSTANT	1.0418	0.333	3.123	0.0018
RELATION	-1.4311	0.396	-3.605	0.0003
UNICOST1-UNICOST2	-0.0627	0.010	-5.876	0.0000
TIME1-TIME2	0.1173	0.184	0.634	0.5259
TRANRATIO	0.0204	0.93E-02	2.177	0.0295

Turning to the specific estimates, in general, the estimates are of expected sign, seem to be of plausible magnitude, and appear to be quite significant. The only exception comes from the time variables, whose difference is not significant.[11] We have considered this an interesting result and thus we have maintained the variables in the model.[12]

The positive sign of the constant indicates that, all else equal, shippers have an inherent preference for purchased transport over own-account. Hiring their transport services is considered by firms to be more convenient than providing them internally.

Also, as the negative sing in RELATION indicates, own-account transport is preferred for the shipment of outputs, rather than inputs. This may suggest that own-account drivers are fulfilling other supplementary tasks and responsibilities, pertaining probably to the marketing sphere.[13],

The negative sing of the cost difference implies that companies are choosing the type of transport with lowest relative price. Consequently, the greater the cost difference, the more probable becomes own-account transport.

Finally, a significant effect is found for the importance of total annual transport costs. As we interpret it, it is a long to medium term variable: when transport costs have a notable impact on a firm's expenditures, the company tries to economize on those transport costs providing for its transport services on the market.

The former interpretation of the results is only based on the sign of the effect of a change in the explanatory variable on the probability of selecting a particular type of transport. But, in a probit model, the magnitude of the effect of a change in a variable cannot be directly represented by the coefficient estimates provided by the calibration (Dunne, 1984). One must calculate marginal effects directly. For a probit model, these marginal effects can be obtained by the following formula (Greene, 1999, p.753):

$$\frac{\partial \Phi(\mathbf{x}\beta)}{\partial X_k} = \phi(\mathbf{x}\beta)\beta_k \qquad [17.]$$

where, as usual, Φ and ϕ denote respectively the normal distribution and density functions. As can be observed, the value of the marginal effect depends both on the parameter estimate and the point of evaluation (Cabrer Borrás et al., 2001,p.117).

[11] In addition, the difference in times should also have a negative sign, as the difference in costs.
[12] Also, the maximized value of the log likelihood function decreased when this variable was eliminated.

Given the above definition, marginal effects can only be computed for continuous variables. However, according to Greene (1999, p.755), marginal effects calculated by the above formula for discrete variables usually give good approximations of the change in the probability of choosing option 1 originated by the presence of the dicotomous variable. Table 10 shows the marginal effects obtained for the probit model, evaluated at sample means.

TABLE 10.- MARGINAL EFFECTS OF THE BINOMIAL PROBIT MODEL.				
Source: Mail questionnaire. Calculations performed using LIMDEP, version 7.0.				
Dependent var. :ACCOUNT NOBS.=106				
Variable	Coefficient	Standard Error	Coef./Stand. Er.	Probability
CONSTANT	0.392	0.1109	3.541	0.0004
RELATION	-0.539	0.1446	-3.732	0.0002
UNICOST1-UNICOST2	-0.024	0.396E-02	-5.978	0.0000
TIME1-TIME2	0.044	0.069	0.635	0.5256
TRANRATIO	0.771E-02	0.356E-02	2.167	0.0307

The estimated values represent the effect of an infinitesimal change of the explanatory variable considered on the probability of choosing purchased transport. Given the above results, the selection of third-party transport versus own-account operations is guided fundamentally by the inherent preference of shippers for purchased transport and the tendency towards serving outputs (compared to inputs) directly to customers. The relative price of the shipment is also important: an increase in the cost difference increases the probability of changing the transport-type option. Finally the relative weight of transport costs has also its effect, but a lesser one.

7.- CONCLUDING OBSERVATIONS

This study analyzes the determinants of freight transport demand relative to the trade-off found for own-account versus purchased transport. The theoretical model postulates the optimization of transport and logistics costs.

The model is applied to data gathered by means of a sample survey conducted on agro-industrial Andalusian enterprises. In line with the works of Jiang et al. (1999) and Fridstrom and Madslien (2002), the empirical implementation of the model clearly

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[13] Fridstrom and Madslien (2002) consider such supplementary responsibilities to be one of the main reasons why many companies cling to this type of transport.

states that the selection of own-account versus purchased transport takes place at the strategic level at a medium term time horizon.

The empirical findings show that, all else equal, purchased transport is favored over own-account. In addition, the probability of selecting for hire transport increases with total transport costs, relative to sales. Conversely, own-account transport is preferred for the shipment of outputs, rather than inputs and when the relative cost of purchased transport increases. The difference in transit time has not been found to be significant in deciding which type of transport to choose.

Further work is clearly needed in order to extrapolate the empirical results of the present paper. As already stated, most studies of the disaggregate approach analyze the truck versus rail trade-off and therefore we lack adequate parameters of comparison. The most interesting options would be the examination of freight transport demand for other industrial sectors in Andalusia or the analysis of agro-industrial shippers' behavior for other geographical regions.

APPENDIX 1

Following Abdelwahab and Sargious (1992), it is assumed that the residuals $\varepsilon_1, \varepsilon_2$ and ε in the system of equations [14-16] are serially independent and have a trivariate normal distribution with mean vector **0** and non-singular covariance matrix $\sum$,[14]

$$\sum = \begin{bmatrix} \sigma_1^2 & \sigma_{12} & \sigma_{1\varepsilon} \\ \sigma_{12} & \sigma_2^2 & \sigma_{2\varepsilon} \\ \sigma_{1\varepsilon} & \sigma_{2\varepsilon} & 1 \end{bmatrix} \quad [18.]$$

Equations [14] and [15] cannot be estimated by ordinary least squares because the conditional expectations of the residuals are non-zeros; that is, $E(\varepsilon_1 \mid I) \neq 0$ and $E(\varepsilon_2 \mid I) \neq 0$. Since sample separation is observed, we have the observations I_t. Thus,

[14] Note that σ_ε^2 has been normalized to one. That can be done without loss of generality (Abdelwahab and Sargious, 1992).

we can apply the maximum likelihood procedure to estimate the reduced-form parameters of the probit model, in what constitutes the first stage:

$$I^* = \theta_0 + \theta_1 \mathbf{s} + \theta_2 \mathbf{s^k} + \theta_3 \mathbf{s^m} - \varepsilon \qquad [19.]$$

With these estimates $\hat{\theta}_0$, $\hat{\theta}_1, \hat{\theta}_2$ and $\hat{\theta}_3$ in hand, one can calculate the selectivity correction factors $\hat{W}_1$ and $\hat{W}_2$ as:[15]

$$\hat{W}_1 = \frac{\phi\left(\hat{\theta}_0 + \hat{\theta}_1 \mathbf{s} + \hat{\theta}_2 \mathbf{s^k} + \hat{\theta}_3 \mathbf{s^m}\right)}{\Phi\left(\hat{\theta}_0 + \hat{\theta}_1 \mathbf{s} + \hat{\theta}_2 \mathbf{s^k} + \hat{\theta}_3 \mathbf{s^m}\right)} \qquad [20.]$$

$$\hat{W}_2 = \frac{\phi\left(\hat{\theta}_0 + \hat{\theta}_1 \mathbf{s} + \hat{\theta}_2 \mathbf{s^k} + \hat{\theta}_3 \mathbf{s^m}\right)}{1 - \Phi\left(\hat{\theta}_0 + \hat{\theta}_1 \mathbf{s} + \hat{\theta}_2 \mathbf{s^k} + \hat{\theta}_3 \mathbf{s^m}\right)} \qquad [21.]$$

And then, these expressions can be appended to equations [11] and [12] so that:

$$X_1^* = \beta_{01} + \beta_{11} \mathbf{s} + \beta_{21} \mathbf{s^k} + \beta_{31} \mathbf{s^m} - \sigma_{1\varepsilon} W_1 + \zeta_1 \qquad [22.]$$

$$X_2^* = \beta_{02} + \beta_{12} \mathbf{s} + \beta_{22} \mathbf{s^k} + \beta_{32} \mathbf{s^m} + \sigma_{2\varepsilon} W_2 + \zeta_2 \qquad [23.]$$

The second stage involves adjusting these two equations. The first one [equation 22] can be estimated by ordinary least squares from sample observations on purchased transport, as $E(\zeta_1 \mid I = 1) = 0$. Similarly, equation [23] becomes estimable by ordinary least squares from sample observations on own-account transport, given $E(\zeta_2 \mid I = 0) = 0$.

According to Maddala (1983, p.225), the resulting estimates of this 'Heckit method' are consistent.

APPENDIX 2

As previously stated, for the variable UNICOST, the inclusion of the correction factors (named LAMBDA in the tables) improves the fit of the models. Tables A.1 and A.2 show the parameter estimates to be used in the predictions of UNICOST1 (purchased transport fare) and UNICOST2 (own-account unit cost) when not chosen by shipper firms.

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[15] These factors are obtained from the properties of truncated normal variables. Maddala (1983, p.224) explains the calculations involved.

TABLE A.1.- SAMPLE SELECTION MODEL FOR UNICOST (PURCHASED TRANSPORT)				
Source: Mail questionnaire. Calculations performed using LIMDEP, version 7.0				
NOBS.=59 N Parameters =4 Deg. Fr. =55				
R squared = 0.17666 Model test: F[3, 55] = 3.63		Adjusted R squared =0.12917 Prob. Value .01692		
Variable	Coefficient	Standard Error	Coef./Stand. Er.	Probability
CONSTANT	12.177	3.702	3.289	0.0010
PERISHABLE	8.631	3.768	2.290	0.0220
ANUAL	-0.26 E-02	0.161 E-02	-1.657	0.0975
LAMBDA	-8.281	4.442	-1.864	0.0623

TABLE A.2.- SAMPLE SELECTION MODEL FOR UNICOST (OWN-ACCOUNT TRANSPORT)				
Source: Mail questionnaire. Calculations performed using LIMDEP, version 7.0				
NOBS.= 47 N Parameters =4 Degrees Fr. =43				
R squared = 0.21563 Model test: F[3, 43] = 3.57		Adjusted R squared =0.15530 Prob. Value 0.02239		
Variable	Coefficient	Standard Error	Coef./Stand. Er.	Probability
CONSTANT	5.881	2.825	2.082	0.0373
VALUE	0.595 E-02	0.212 E-02	2.811	0.0049
DISTANCE	0.137 E-01	0.753 E-02	1.830	0.0673
LAMBDA	5.075	3.694	1.374	0.1695

For the variable TIME, a simple ordinary least-squares regression model is employed, as the correction factors appear to be non-significant. Estimates for the purchased transport option and for the own- account alternative are presented in Tables A.3 and A.4, respectively.

TABLE A.3.- OLS MODEL FOR TIME (PURCHASED TRANSPORT)				
Source: Mail questionnaire. Calculations performed using LIMDEP, version 7.0				
NOBS.=59 N Parameters =4 Deg. Fr. =55				
R squared = 0.16794 Model test: F[3, 55] = 3.63		Adjusted R squared =0.12172 Prob. Value .01841		
Variable	Coefficient	Standard Error	Coef./Stand. Er.	Probability
CONSTANT	1.936	0.429	4.510	0.0000
PERISHABLE	-1.092	0.522	-2.093	0.0410
BULK	-1.131	0.666	-1.698	0.0952
DISTANCE	0.899 E-03	0.438 E-03	2.051	0.0451

TABLE A.4.- OLS MODEL FOR TIME (OWN ACCOUNT TRANSPORT)				
Source: Mail questionnaire. Calculations performed using LIMDEP, version 7.0				
NOBS.= 47 N Parameters =4 Degrees Fr. =43				
R squared = 0.30133 Model test: F[2, 43] = 9.06		Adjusted R squared =0.26807 Prob. Value .00054		
Variable	Coefficient	Standard Error	Coef./Stand. Er.	Probability
CONSTANT	0.0620	0.114	5.414	0.0000
FARE	0.683 E-02	0.766 E-02	0.891	0.3778
DISTANCE	0.150 E-02	0.380 E-03	3.945	0.0003

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